

DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Office of Flexible Pavement Materials
5900 Folsom Blvd.
Sacramento, California 95819-4612



Hot Mix Asphalt (HMA) using up to 15% Reclaimed Asphalt Pavement (RAP)

1. SCOPE

- 1.1 Reclaimed asphalt pavement (RAP) may be combined with virgin aggregate and new asphalt binder at a central mixing plant to produce hot mix asphalt (HMA).
- 1.2 This lab procedure is applicable to all HMA mixtures containing up to 15% RAP aggregate in the aggregate blend.
- 1.3 RAP is not allowed in rubberized asphalt concrete (RAC) and open-graded mixtures.
- 1.4 Physical properties of the asphalt extracted from RAP and RAP aggregate will not be tested.

2. SUMMARY OF METHOD

- 2.1 Obtain representative samples of the RAP (See Section 3).
- 2.2 Evaluate the RAP (See Section 4). Determine:
 - a) Amount of asphalt binder
 - b) Aggregate gradation
 - c) Theoretical maximum specific gravity using CT 309 (Rice).
- 2.3 Prepare the mix design (See Section 5):
 - a) Determine the combined gradation of the HMA mixture based on proposed proportions of RAP and virgin aggregate to be used.
 - b) Determine the approximate bitumen ratio (ABR) of the combined aggregate.
 - c) Calculate the amount of new asphalt binder in the HMA mixture.
 - d) Calculate batch weights for each ingredient in the mixture.
 - e) Prepare and test specimens using Hveem apparatus.
 - f) Determine the optimum bitumen content (OBC).
- 2.4 Conduct testing during production (See Section 6).

3. RAP SAMPLING

- 3.1 For the mix design, a minimum of 3 separate representative samples of RAP (minimum 40 lbs. each) shall be obtained in accordance with the applicable sections of CT 125, Part 1, except processed RAP may be sampled from stockpiles.
- 3.2 During production, representative samples of RAP shall be obtained in accordance with the applicable sections of CT 125, Part 1, and the following:

- Batch Plant – Samples shall be taken from the RAP system as it is discharged into the weigh hopper (CT 125, Part 1, Section 1).
- Continuous Mixing Plant – Samples shall be taken from the RAP system as it enters the pugmill or drier-drum mixer (CT 125, Part 1, Section 2).

4. RAP EVALUATION

- 4.1 Prepare each RAP sample separately for evaluation.
- 4.2 Particles of RAP shall be separated by hand so that the particles of the fine aggregate portion are no larger than ¼-inch. Care shall be taken to avoid fracturing the aggregate.
- 4.3 Samples shall be prepared in accordance with CT 201. Split or quarter each sample into representative portions for ASTM D 2172, CT 382, and CT 309 testing. After the required test samples have been prepared, combine the remaining RAP material for subsequent splitting into representative mix design test samples.
- 4.4 Determine the asphalt binder content of each RAP sample using ASTM D 2172, Method B (3 minimum). Calculate and report the individual and average asphalt binder content. Perform a sieve analysis on each sample of recovered aggregate in accordance with CT 202, Appendix A (3 minimum). Calculate and report the individual and average gradation.
- 4.5 Burn asphalt from each RAP sample in accordance with CT 382 for aggregate gradation (3 minimum). Calculate and report the individual and average asphalt binder content (for information only). Perform a sieve analysis on each sample of recovered aggregate in accordance with CT 202, Appendix A (3 minimum). Calculate and report the individual and average gradations.
- 4.6 Determine a correlation factor to be used for RAP gradation testing during production. The correlation factor for each sieve shall be determined by taking the average gradation of the ASTM D 2172 samples minus the average gradation of the CT 382 samples.
- 4.7 If voids in mineral aggregate (VMA) is specified, determine the theoretical maximum specific gravity (Rice) of each RAP sample in accordance with CT 309, Section J (3 minimum). Calculate and report the individual and average values.

The above procedures are summarized in Table 1:

Table 1 – RAP Evaluation

Tests	Sample			Description
	1	2	3	
ASTM D 2172, Method B	X	X	X	Report individual and average asphalt contents to 0.1%
CT 202, Appendix A				Report individual and average gradation results for each sieve.
CT 382 for	X	X	X	Report individual and average asphalt contents to 0.1% (for information only).
CT 202, Appendix A				Report individual and average gradation results for each sieve.
CT 309, Section J	X	X	X	Report individual and average results.
Determine Aggregate Gradation Correlation Factor	X			Average gradation of ASTM D 2172 minus average gradation of CT 382

5. MIX DESIGN

- 5.1 Determine the RAP percentage that will be used in the mix design (maximum 15% RAP aggregate in the aggregate blend).
- 5.2 Determine the combined gradation of the HMA mixture based on proposed proportions of RAP and virgin aggregate to be used in accordance with CT 202.
- 5.3 Determine “K” values of the virgin aggregate portion using CT 303.
- 5.4 Determine the ABR of the combined aggregate gradation as follows:

$$ABR = \frac{4R + 7S + 12F}{100}$$

Where:

ABR = Approximate Bitumen Ratio (total asphalt content).

R = % retained on the No. 8 sieve.

S = % passing the No. 8 sieve and retained on the No. 200 sieve.

F = % passing the No. 200 sieve.

- 5.5 Calculate batch weights for each ingredient in the mixture using the provided batching sheet.

(Note: When using RAP in HMA mix designs, the aggregate gradations and total asphalt content are altered slightly from original batch percentages due to the asphalt contained in the RAP.)

- 5.6 The RAP shall be oven dried to a constant mass in accordance with CT 226, except the temperature shall not exceed 100°F.
- 5.7 Prepare and test specimens (virgin aggregate, RAP, and new asphalt binder) in accordance with CT 304 except as follows:
 - a) If treating aggregate with lime (anti-strip) is specified, only the virgin aggregate shall be treated. Treating the RAP with lime is not required.
 - b) Virgin aggregate shall be heated to 20°F above mixing temperature and RAP shall be heated to 230°F for a maximum of 2 hours. RAP shall not be reheated.
 - c) Add the proper amount of virgin aggregate to the mixing bowl and then add the proper amount of RAP. Dry mix for a minimum of 10 seconds. Add the proper amount of asphalt binder and proceed with wet mixing.
 - d) Use CT 309 to measure theoretical maximum specific gravity (Rice) in accordance with LP-1, in lieu of calculating maximum specific gravity in CT 367.
 - e) Lab Procedure 2 (LP-2) shall be used to calculate VMA.
 - f) Otherwise, normal mix design procedures shall be followed.

6. TESTING DURING PRODUCTION TO VERIFY JOB MIX FORMULA (JMF)

- 6.1 During production, sample and test as normal except as follows:
 - a) Asphalt Content - When developing a correction factor for asphalt content (CT 379 or 382), include the proposed portion of RAP. A new correction factor will not be required unless the RAP proportion changes by more than 5% from the JMF.

Samples for determining asphalt content shall be taken in accordance with CT 125, Part 7.

- b) Aggregate Gradation - When determining the combined gradation, burn off the RAP sample in accordance with CT 382. Report the asphalt content of the RAP sample to 0.1% (for information purposes only). Perform a sieve

analysis on recovered aggregate in accordance with CT 202, Appendix A. Add the correlation factor established in Section 4.6. Report the actual gradation, the correlation factor, and the corrected gradation for each sieve size. Mathematically combine the virgin and corrected RAP aggregate gradations at the correct proportions to obtain the combined gradation.

7. EXAMPLE

(See spreadsheet)